Ambient LOX Impact Testing

NASA-STD-6001: Test 13A

! This Instruction Contains Descriptions of **HAZARDOUS OPERATIONS** !

Materials and Processes Laboratory
Materials Test Branch, Building 4623

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Release Authority	Name	Title	Organization	Date
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This document baselines the EM10 Organizational Work Instruction (OWI) for performing ambient-pressure liquid oxygen (LOX) impact tests in Marshall Space Flight Center's (MSFC's) Building 4623. Any deviation to this procedure shall be approved by the test engineer via an approved test plan. Any changes to the test equipment shall be noted on the tester maintenance log and approved by the test engineer. It is the responsibility of the test engineer to obtain NASA Contracting Officer's Technical Representative (COTR) approval where necessary for changes to the test equipment.

Any change to this OWI shall be submitted to and approved by the Materials Test Branch Chief, EM10. Revisions may also be submitted to the concurring organizations listed below for review and concurrence by memo. The original OWI and all changes shall be maintained by EM10. Any change to materials used requires a change to mechanical drawings, in addition to Chemistry Team Leader approval. All documentation shall be approved by the appropriate persons mentioned above and incorporated into the OWI before operation of the reconfigured test equipment can resume.

Concurring organizations:
Building 4623 Test Operations Contractor
Chemistry Team Leader
Environmental Health, AD60M

Contents

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1.0 Scope

1.1 Scope

The scope of this operating instruction is NASA-STD-6001, Test 13A, Mechanical Impact for Materials in Ambient Pressure LOX, as performed in Building 4634 at Marshall Space Flight Center.

1.2 Purpose

The purpose of Test 13A is to determine the mechanical impact sensitivity of materials when exposed to liquid oxygen at ambient pressure.

1.3 Applicability

This instruction applies to the Chemistry Team, Materials Test Branch, of the Materials and Processes Laboratory.

2.0 Applicable Documents

ASTM D 2512-82. *Standard Test Method for Compatibility of Materials with Liquid Oxygen (Impact Sensitivity Threshold and Pass-Fail Techniques).* 1982.

EM10-OWI-CHM-042. *Test Sample Preparation for Testing in Building 4623.*

EM10-OWI-CHM-050. *Building 4623 Guidelines for Test Operations*.

EM10-OWI-CHM-051. *Receipt, Handling, Prioritizing, and Data Requirements of Samples Submitted for Testing in Building 4623 of the Materials and Processes Laboratory*.

EM10-OWI-CHM-058. *Chemical Hygiene Plan for Building 4623.*

MPD 1840.3. *MSFC Respiratory Protection Program*.

MPR 1040.3. *MSFC Emergency Plan*.

MPR 1840.2. *MSFC Hazard Communication Program*.

MPR 8715.1. *MSFC Safety, Health, and Environmental (SHE) Program*.

MSFC-SPEC-164B. *Specification for Cleanliness of Components for Use in Oxygen, Fuel, and Pneumatic Systems.*

MWI 3410.1. *Personnel Certification Program*.

MWI 8621.1. *Close Call and Mishap Reporting and Investigation Program*.

NASA-STD-6001. *Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion.*

NHB-8060.1B. *Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion.*

Note: Always reference the current version of an applicable document.

3.0 Definitions

3.1 Definitions

Blank. A one-piece or two-piece specimen cup containing only an insert.

Disk. An anodized aluminum-alloy disk used as a carrier for dyes, dye penetrants, and emulsifiers.

Full access. A term meaning, "Anyone may enter the test cell."

Insert. A 300-series stainless-steel disk placed in the bottom of the specimen cup.

Limited access. A term meaning, "Only the test operator shall enter the test cell with appropriate personal protective equipment."

Mechanical impact. Energy delivered to a sample by a plummet that has been dropped from a pre-established height onto a striker pin in contact with the sample.

NASA. Marshall Space Flight Center EM10 responsible personnel.

No access. A term meaning, "No one shall enter the test cell."

One-piece insert cup (grease cup). An aluminum-alloy cup placed in the bottom of the one-piece specimen cup. Used for liquid and semisolid samples. Occasionally, stainless-steel insert cups are used.

Oxygen deficient. Oxygen level in air is less than 19.5%.

Oxygen enriched. Oxygen level in air is greater than 23.5%.

Reaction. A chemical change or transformation in the sample resulting from mechanical impact and determined by an audible report, a visually detected flash, sustained burning, or obvious charring of the sample, sample cup, or striker pin.

Specimen cup. An aluminum-alloy cup used for solid and liquid samples.

Tag out. Placement of a tag-out device on an energy-isolating device to indicate that the energy-isolating device and equipment being controlled shall not be operated until the tag-out device is removed by the person who placed it there.

Test 13A. Mechanical impact testing for materials in ambient pressure LOX per NASA-STD-6001.

Test area. The portion of Building 4623 and fenced area south of the north wall of Room 122.

Test cell. Room 122A of Building 4623, which contains the impact testing equipment.

Test engineer. The person responsible for correctly following the approved test plan for a specific test -- from sample receipt to test data evaluation.

Test operator. The person responsible for conducting a test under the guidance of the test engineer.

3.2 Acronyms

GN_2	Gaseous nitrogen
LED	Light Emitting Diode
LN_2	Liquid nitrogen
LOX	Liquid oxygen
MSDS	Material Safety Data Sheet
MSFC	Marshall Space Flight Center
OWI	Organizational Work Instruction
PTFE	Polytetrafluoroethylene

4.0 Instructions

All operations of this equipment shall be conducted using the applicable documents referenced above (section 2). All data and test results shall be recorded on form EM10-F-CHM-013, the Test 13A Test Data Sheet (section 7.2, Figure 2). A summary of pertinent test information and test results shall be compiled in a memorandum, signed by the test organization management, and mailed to the test requester.

4.1 Sample Preparation

The *sample preparation technician* **shall prepare** Test 13A samples according to EM10-OWI-CHM-042, *Test Sample Preparation for Testing in Building 4623.* When non-standard samples are received, the *sample preparation technician* **shall follow** the directions written in the test plan for that test request. *If this information is not provided with the test plan*, the *sample preparation technician* **shall seek clarification** from the test engineer.

Before testing begins, the *test operator* **shall review** the information supplied on the test data sheet (prepared by the sample preparation technician) to make certain the information is complete and appears sound. *If a problem is identified*, the *test operator* **shall notify** the test engineer. The *test operator* shall also*:*

- **Verify** that the test request number and material designation are identical on all paperwork.
- **Confirm** that the prepared samples agree with the test request.
- **Verify** that the sample preparation technician has noted if the sample has been cleaned or if the sample does not need to be cleaned.
- **Note** any flaws or imperfections in the sample, and **record** these on the test data sheet.
- **Review** the signed test plan and the original test request before proceeding. *If the test plan and the test request do not agree*, **request** clarification from the test engineer.

4.2 Pre-Test Photography

The *sample preparation technician* **shall take** a pre-test photograph of at least one of the samples and **place** three copies of the photograph in the test folder. *If the pre-test photograph has not been taken*, the *test operator* **shall take** the photograph and **place** three copies of the photograph in the test folder before proceeding with the test. The entire sample shall be visible in the photo. Steps for photographing samples are outlined in the *Photography Operating Guide*.

4.3 Equipment Checkout

At the beginning of the test day, the *test operator* **shall perform** the following steps:

4.3.1. **Observe** at the oxygen monitor station located in Room 116. **Locate** the monitor for Room 122A. **Ensure** that the digital LED readout indicates a normal oxygen level (19.5 to 23.5%) before entering the test cell.

4.3.2. **Ensure** that the test cell floor and the room behind the test cell are visibly clean. *If conditions warrant*, **scrub** the floor of the cell with a detergent solution, and **rinse** with water.

4.3.3. **Check** the plummet assembly before each test request. **Ensure** that the plummet spiders are securely attached to the plummet body and that bearing wheels are securely mounted on the spiders; **use a wrench to tighten** these as needed. *If any bearings are missing,* **replace** these before testing. **Ensure** that the spiders are in proper alignment with the test stand columns and that bearing wheels rotate freely. **Verify** that the clamp on the magnet housing is secure. (**Use** a wrench if necessary.) Ensure that all guide track retaining bolts are hand-tight. *If not*, **notify** the test engineer who shall call the Fabrication Group to come align the track(s) and tighten the bolt(s). To ascertain the alignment of the vertical guide tracks and the error caused by friction of the plummet assembly, **time** the plummet fall from a given height. For this test, the free-fall timing is to be within 3% of the value given for the associated height (section 7.2, Table 1).

4.3.4. **Check** the anvil plate for indentations or other irregularities. **Examine** the concrete pedestal for any crumbling. **Examine** the rails for bends or large scratches. **Report** any problems to the test engineer.

4.3.5. **Ensure** the proximity switches (timing sensors), electromagnet, mechanical safety catch, exhaust fan, and the facility warning beacon are working. **Report** problems to the test engineer before making any adjustments.

- **Refer** to section 7.2, Table 1, for drop times.
- **Raise** the plummet to the magnet base to test the electromagnet and safety catch.
- **Turn on** the exhaust fan, and **listen** for operation.
- **Turn on** the facility warning beacon.

CAUTION: Verify proper operation of the safety catch before working in the plummet fall/impact path.

4.3.6. **Thoroughly clean** the guide tracks, plummet, anvil plate, striker-pin guide, specimen-cup holder, baseplate, sample holder top plate, hand dewars, forceps, sample freezing box, and measuring rods to be used. **Use** cheesecloth soaked with deionized water and non-ionic soap. **Rinse** with deionized water. *If the*

equipment is oily or greasy, **clean** it again with fresh trichlorotrifluoroethane. Trichloroethylene or Brulin® 815 MX may be substituted for trichlorotrifluoroethane, *if the cleaning is performed in a well-ventilated area.* **Allow** parts to dry completely before assembly.

Note: **Discard** any rags and debris soaked with trichlorotrifluoroethane (or organic materials) in the *Organic Rags and Debris* hazardous control drum, which is located in Room 128 (in the fenced area south) of Building 4623. **Do not discard these rags in any other receptacle.**

4.3.7. **Clean** the pre-cooling moat by placing all parts in the ultrasonic cleaner with a mixture of non-ionic soap and deionized water for 20 minutes. **Rinse** with deionized water. *If parts are still dirty or need further cleaning,* **wipe** each part with trichlorotrifluoroethane. Trichloroethylene or Brulin® 815 MX may be substituted for trichlorotrifluoroethane, provided the cleaning is performed in a well-ventilated area. **Allow** parts to dry completely before assembly. **Clean** and **store** equipment after use.

4.4 System Setup and Sample Loading

The *test operator* **shall perform** the following steps:

4.4.1. **Inspect** the contents of the current test folder to ensure that the following information is provided:

- Test request
- Signed test plan
- Test data sheets
- Sample preparation sheet
- Test material's MSDS or the Exclusion Statement for the material/component being tested
- Pre-test photographs (**See** section 4.2.)
- Ambient-Pressure LOX Impact Tester Pre-Test Checklist.

WARNING: Read the test material's MSDS to ensure familiarity with all safety precautions associated with the material. Verify that the test engineer is aware of all highly hazardous, reactive, or toxic components of the test material. The *test engineer* shall direct the test operator in proper safety procedures concerning these test materials.

4.4.2. **Turn on** warning lights to indicate that hazardous testing is in progress. This places the test area in a *limited-access* condition.

4.4.3. **Ensure** that adequate supplies of LN_2 and LOX are available for testing purposes. *When needed*, **change out** the empty LOX dewars, and **cap** both the tap

and vent. **Use** hearing protection when moving or releasing LOX from dewars. **Ensure** that the flex line and diffuser tube do not hit the floor. **Report as unusable** any parts whose cleanliness is questionable; **send** these to the responsible cleaning agency.

4.4.4. **Don** PPE (safety shoes, safety glasses, latex gloves).

4.4.5. **Assemble** the pre-cooling moat, and **install** it on the test stand as follows:

CAUTION: Verify proper operation of the safety catch before working in the plummet fall/impact path.

a. **Place** the LN_2 moat atop the baseplate so that the hex head bolt holes are aligned and the open gap in the moat is facing the control room (north).
b. **Place** the anvil into the LN_2 moat so that the bolts align with the hex head bolt holes in the bottom of the moat.
c. **Place** the sample holder top plate on top of the anvil.
d. **Insert** two bolts through the bolt holes.
e. T**ighten** the two 9/16-in. hex head hold-down bolts, torquing each to 10 ft-lb (120 in.-lb) maximum.
f. **Screw** in the striker pin guide, aligning the stud (northeast corner) and the striker pin guide swivel (southeast corner).
g. **Place** the striker pin guide over the aligning stud and the guide swivel.
h. **Place** the striker pin guide swivel spring onto the guide swivel, on top of the striker pin guide, and **screw** on the striker pin guide swivel nut.
i. **Insert** the LN_2 feed-line nipple through the opening in the LN_2 moat. **Place** the nut and washer onto the nipple, and **tighten** the nut snugly by hand.
j. **Place** the metal splash guard, flange side down, over the LN_2 nipple where it comes through the LN_2 moat.

4.4.6. **Adjust** the magnet housing assembly to the height needed to achieve the desired energy level (section 7.2, Table 1) by performing one of the following procedures:

4.4.6.1. Procedure 1

4.4.6.1.1. **Load** a blank and a striker pin in the test position.

4.4.6.1.2. **Place** one end of the rod labeled with the appropriate heights on top of the striker pin.

4.4.6.1.3. **Ensure** that the other end of the rod is in contact with the nose (lower end) of the plummet.

4.4.6.1.4. **Tighten** the magnet housing in place.

4.4.6.1.5. **Remove** the rod.

4.4.6.2. Procedure 2

4.4.6.2.1. **Load** a blank and a striker pin in the test position.

4.4.6.2.2. In the control room, **use** the magnet switch on the control console to **release** the plummet so that it falls onto the safety catch.

4.4.6.2.3. In the test cell, **support** the plummet, and **use** the foot switch to disengage the safety catch.

4.4.6.2.4. **Carefully lower** the plummet until it is resting on top of the striker pin.

4.4.6.2.5. **Place** one end of the rod labeled with the proper heights on top of the plummet.

4.4.6.2.6. **Ensure** that the other end of the rod is in contact with the bottom of the magnet housing.

4.4.6.2.7. **Tighten** the magnet housing in place.

4.4.6.2.8. **Remove** the rod.

Note: The proximity switch for the timer moves with the magnet housing assembly to the proper position for the test.

4.4.7. **Turn on** power for the control panel. **Ensure** the timer unit is plugged in. **Turn on** the power supply for the magnet.

4.4.8. **Start** LN_2 flow to cool the base using either facility LN_2 or LN_2 dewars, as described below:

4.4.8.1. *When using facility LN_2*:

- **Ensure** that the line connecting the LN_2 dewar is disconnected and capped.
- **Open** the LN_2 valve behind the test cell in Room 122. **Don** latex gloves, laboratory coat and safety glasses, and **open** the moat valve on the base to allow LN_2 to fill the moat and cool the base. As an option in warm weather, **open** the main LN_2 valve behind the test cell in Room 118 to speed the process of chilling the base. This step can be performed earlier in the procedure.

- **Run** LN_2 until the base is capable of holding LOX; **allow** approximately 45 minutes of chilling time, depending on the outdoor temperature. **Pause** during testing to rechill the base as needed.

4.4.8.2. *When running on LN_2 dewars:*

- **Ensure** that the LN_2 valve behind the test cell in Room 122 is closed before uncapping the dewar line.
- **Uncap** the dewar line, and **attach** it to the liquid port of the LN_2 dewar.
- **Open** the LN_2 valve on the dewar. **Don** PPE; then **open** the moat valve on the base to allow LN_2 to fill the moat and cool the base.
- **Run** LN_2 until the base is capable of holding LOX; **allow** approximately 45 minutes of chilling time, depending on the outdoor temperature. **Pause** during testing to rechill the base as needed.

4.4.9. While the base is cooling, **prepare** the striker pins and the sample freezing box. **Use** either of the two methods described below:

WARNING: Do not use glass dewars for transfer of cryogenic liquids.

4.4.9.1. Standard Chilling Method

- **Fill** an additional clean dewar with LOX for ladling into the sample tray and specimen cups.
- **Place** pins in a small clean dewar, and **fill** the dewar with enough LN_2 to cover pins with approximately 2 in. of liquid.
- **Ensure** that the sample freezing box is level. **Fill** the sample freezing box with LN_2. **Place** the sample tray containing 20 prepared samples and a minimum of 5 blanks in the sample freezing box. **Wait** approximately 30 minutes, and **fill** the sample tray slowly with LOX until the sample cups are filled and the tray is filled to within 1/8 in. of its top.
- **Reject** any samples showing voids or holes. **Check** that the sample material has not separated from the bottom of the cup. Using tongs, **submerge** samples that separate. **Do not reject** cracked samples.
- **Ensure** that storage at this stage of the procedure does not exceed 4 hours and that sample cleanliness is maintained.

4.4.9.2. Alternate Chilling Method

- **Inspect** the striker pins for cleanliness and the striker-pin surface for smoothness. **Refer** to section 9.3, Required Tester Maintenance, *if there are any concerns*, and **inform** the test engineer. **Place** 25 clean, smooth pins in a small, clean, hand dewar.
- **Partially fill** the clean hand dewar containing striker pins with LN_2; **cover** all pins with 2 in. of LN_2.

- **Fill** an additional clean hand dewar with LOX for ladling into the specimen cups and the sample well.
- **Ensure** that the sample freezing box is level. **Remove** 20 prepared samples and a minimum of 5 blanks from the pan. **Place** these in the sample freezing box over the holes in the retainer plate. **Begin filling** the freezing box with LOX. **Fill** the freezing box and the cups to 1/8 in. from the top of the box.
- **Reject** any samples showing voids or holes. **Ensure** that sample material has not separated from the bottom of the cup. Cracked samples do not necessarily have to be rejected. **Inform** the test engineer of any problems.
- **Ensure** that storage at this stage of the procedure does not exceed 4 hours and that sample cleanliness is maintained.

4.4.10. **Complete** the Pre-Test Checklist (section 7.2, Figure 1).

4.4.11. **Turn off** the moat valve. **Don** face shield, laboratory coat, and latex gloves; then **blow** ice and debris from the sample well with filtered GN_2. **Blow out** all LN_2 to prevent dilution of LOX with LN_2.

4.4.12. **Check** the timing sensor before each drop to ensure proper positioning on the magnet base in relation to the plummet. The light on the sensor **shall be off** before the test begins.

4.4.13. **Don** latex gloves. **Use** steel forceps to place a chilled specimen cup containing a chilled sample or blank into the base cavity. The first two cups **shall** be blanks to ensure the cleanliness of the system.

4.4.14. Using steel forceps, **place** the striker pin on top of the blank or sample.

Note: *If aligning striker pin with gloved hands,* **do not touch** the impact surface of the pin.

4.4.15. **Check** the striker-pin guide assembly to ensure that both guide pins are perpendicular to the guide plate, that the guide plate rotates freely with the spring, and that the guide plate is not bowed.

4.4.16. **Slide** the striker-pin guide over the striker pin, and **ensure** that the striker pin is perpendicular to the sample.

4.4.17. **Ladle** LOX into the specimen cup, *if the specimen is not covered with LOX.*

4.5 Detailed Test Procedure

The *test operator* **shall perform** the following steps:

4.5.1. After completing system setup and sample loading, **ensure** there is no illumination other than the overhead light in the cell. **Proceed** to the control room, ensuring that the door between the test cell and control room is closed securely. After this step, *no access* to the test area shall be allowed.

4.5.2. At the control console, **reset** the **RED** velocity switch and the timer. **Ensure** that the timer reads **0.000 s** and is not running.

4.5.3. **Place** hand on the catch and magnet switches, and **ensure** an unobstructed view of the sample cup/striker pin configuration.

4.5.4. **Turn off** all lights in the test cell and control room area. (The light switches are to the right of the observation window.) **Release** the safety latch and magnet, in that order, by pushing up on the switches. **Observe** and **listen** to the drop. **Count** the number of rebounds, and **note** if a flash or audible report occurs on impact, first rebound, second rebound, etc.

4.5.5. **Turn on** all lights. On the test data sheet (section 7.2, Figure 2), **record** the drop time, any observations (visible flash, audible report, etc.), and when these observations occurred (first impact, first rebound, second rebound, etc.). The drop time **shall be** within 3% error, in accordance with Table 1, section 7.2.

CAUTION: Verify proper operation of the safety latch before working in the plummet fall/impact path.

4.5.6. *Limited access* to the test area is allowed at this point. **Don** latex gloves, clean laboratory coat, safety glasses, and any other personal protective equipment identified by the sample MSDS. **Re-enter** the test cell, **reposition** the plummet, and **verify** engagement of the safety latch. *If there is a noticeable odor,* **note** this on the test report.

4.5.7. **Lift** the striker-pin guide, **remove** the striker pin, and **observe** the striking surface. Then, **use** forceps to remove the specimen cup. **Save** the sample as tested, so that after the sample has warmed, the sample, specimen cup, inserts, and any substrates **shall** be examined for signs of obvious charring.

4.5.8. **Repeat** steps 4.4.11 through 4.4.17 and steps 4.5.1 through 4.5.7 for samples 2 through 20. **Test** a blank after every 5 samples to ensure that the test system is still clean. *If any samples react*, **test two blanks** after the reacted sample before continuing with the remaining samples. Any time a reaction occurs when dropping on a blank, **cease** all testing, and **blow** debris from the sample well with filtered GN_2. **Resume** testing with two blank tests. *If a reaction occurs again*

on a blank, **cease** testing, **thaw** the equipment, **clean** the base and plummet, **reassemble** the tester, and **resume** testing with two blanks.

4.5.9. On the test data sheet, **enter** observations of charred or burned defrosted test items.

4.5.10. **Do not reuse** inserts and insert cups. *If the sample reacted,* **photograph** the sample, **save** the insert, and **package** it with the sample tested. *If the sample did not react,* **discard** the insert. **Save** and **package** all insert cups.

4.5.11. *If another test with a different material is to be performed*, **change** out the base.

4.5.12. The test plan shall define the energy thresholding procedure. The following describes a general energy thresholding procedure:

Start testing at an impact energy of 72 ft-lb unless otherwise specified. **Test** in decrements of impact energies (drop heights) as listed in section 7.2, Table 1. *If no reactions occur in 20 drops or if 1 reaction occurs in 60 drops,* testing is complete. Upon 2 reactions, **drop** to the next energy level as noted in section 7.2, Table 1. **Continue to drop** the energy level until no reactions are observed in 20 drops or 1 reaction is observed in 60 drops; When this condition is met, testing is completed.

If the sample is depleted before thresholding is complete, **note** this on the test plan, and **discontinue** testing. The *test engineer*, in consultation with NASA, shall decide all questionable reactions. **Report** any violent reactions or anomalies with testing to the test engineer, who, with NASA's approval, shall decide whether to continue testing.

4.6 Shutdown Procedure

The *test operator* **shall perform** the following steps:

4.6.1. **Don** latex gloves, clean laboratory coat, safety shoes, goggles, and other personal protective equipment identified by the LN_2 and LOX MSDSs. **Close** the LN_2 valve at the source, and then **close** the LN_2 valve at the moat. Closing the valves in this order ensures that no LN_2 remains trapped in the line between the valves.

4.6.2. **Place** a fan so that it blows on the base. **Turn on** the dehumidifiers.

4.6.3. *When the stand has thawed sufficiently,* **lift** the metal plate, and **check** for LN_2/LOX. *If none is visible*, **disassemble** the base by performing section 4.4.5, steps a through j, in reverse.

4.6.4. **Turn off** the facility warning beacon to indicate that *full access* to the test cell is allowed at this point.

4.6.5. **Cover** the LOX diffuser on the LOX dewar with aluminum foil.

4.6.6. As soon as practical, **perform** data recording and post-test photography in accordance with section 4.7.

4.6.7. **Secure** the test area , *i.e.,* **close** and **lock** all doors leading from the test area to the outside of the facility. **Turn off** all lights in the test area.

4.7 Data Recording and Reduction; Post-Test Photography

The *test operator* **shall perform** the following steps:

4.7.1. **Complete** the test report data sheets (section 7.2, Figure 2). **Place** these sheets and the completed Pre-Test Checklist (section 7.2, Figure 1) in the test folder.

4.7.2. **Photograph** reacted samples, charred or melted test equipment, or any anomalies. **Document** these in writing on the test report data sheet. **Do not photograph** post-test samples that did not react. **Take** photographs as close to the samples as possible. More than one sample or reaction per photograph is acceptable, if the details of reactions are visible. **Refer** to the *Photography Operating Guide* for procedures for taking photographs. **Place** three copies of each post-test photograph in the test folder before returning the folder to the engineer. Photographs shall be retained indefinitely.

Note: *If there are several reactions and samples are hard to handle,* representative photos may be taken and labeled as such. The test engineer, in consultation with NASA, **shall decide** whether to make representative photos on a case-by-case basis.

Package samples and inserts from reacted samples in clear photography slide sleeves. **Label** the protector with the test request number, NASA-STD-6001 test type, temperature at which the test was performed, reactions per number of samples tested, pressure at which the test was performed, and the date. **Use** a red pen to label reacted samples; **use** a black pen to label all other samples. **Identify** the sample by sample number. **Return** the samples with the test folder to the test engineer for evaluation. The *test engineer* **shall return** samples to the *sample preparation technician* who **shall store** them for future reference.

5.0 Notes

Custodians for EM10-OWI-CHM-032	
Master List and Document Control	EM10 Management Support Assistant
Alternate Document Control	EM10 ISO Representative
Records	Materials Test Branch ISO Representative
Calibration	Materials Test Branch Calibration Contact
Memoranda	Materials Test Branch ISO Representative

6.0 Safety Precautions and Warning Notes

6.1 Hazards

Warning
Death, severe personal injury, or loss of major equipment may result if maintenance or operating procedures, techniques, restrictions, etc., are not followed exactly.

Safety shall have precedence over all activities. Because of the nature of testing materials in a LOX environment, the testing system involves several hazards to the operator and facility. Personnel conducting ambient pressure LOX impact testing may be exposed to the following hazards:

- Handling and pouring of cryogenic fluids
- Exposure to an oxygen-deficient environment
- Flammability and health risks from volatile cleaning solvents
- Handling and moving of heavy parts of the test apparatus on a regular basis
- Potential of explosion and hazardous fume by-products from burning materials in a pure oxygen or oxygen-enriched environment
- Electrical shock related to operation of equipment
- Potential touch temperature risks from cryogenic LOX tests when handling test equipment
- Pressurized systems with nitrogen
- Potential of impact plummet disengaging during assembly or disassembly of the impact chamber, creating risks of dismemberment, dislocation, or fracture.

6.2 Safety Precautions

6.2.1. Personnel shall **plan** test setup, testing, and shutdown so that at least one test operator is in the test area and one other person is in Building 4623 during normal business hours. After normal business hours and on weekends, a test engineer shall be in Building 4623 during all test activities. **No more than five personnel** shall be in the test area at any given time. Operation of tests shall comply with EM10-OWI-CHM-050, *Building 4623 Guidelines for Test Operations.*

6.2.2. When personnel are working with the tester, the controls shall not be **operated**. A sign warning that personnel are working in the test cell shall be placed on the control console.

6.2.3. Personnel shall **refer to the MSDS** for information on personal protective equipment for materials being handled (sample materials, solvents used, gaseous nitrogen, liquid nitrogen, and liquid oxygen) and **shall wear** safety apparel appropriate for test specimens and conditions:

- Safety shoes when there is a danger of foot injuries from falling or rolling objects, objects piercing the sole of the shoe, or when feet may be exposed to an electrical hazard

- Clean laboratory coats when working with enriched oxygen or other oxidizers, combustion by-products, compressed gases, or flammable solvents
- Chemically resistant goggles and gloves while cleaning test equipment and while working with solvents
- Clean thermal gloves and goggles when pouring, handling, or transferring cryogenic fluids. Hydrocarbon residue can contaminate equipment and affect oxygen compatibility test results or damage the tester.
- Face shield when blowing LN_2 out of the base
- A respirator when working with solvents in closed or poorly ventilated spaces. **Note** that the appropriate respirator shall be worn as indicated on the MSDS. Cartridge respirators are only good for the constituents listed on the filtration cartridge and for dust particle filtration. Personnel shall be qualified to use the respirator, and the respirator shall be supplied by MSFC.
- Hearing protection during testing
- Safety glasses at all times while in the test cells.

6.2.4. Serious tissue damage can occur on exposure to cryogenic LOX or LN_2, cold vapors, or cold equipment. *If injury occurs*, personnel **shall call 911** and **ask** for medical assistance. Bystanders can **(but are not required to)** do the following:

- *If it is safe to do so*, **remove the person** from the source of cold.
- *In the event of full-body cryogenic exposure and if it is safe to do so*, **remove the person** from the exposure atmosphere, and **keep the person's airway open. Loosely wrap the person** in a blanket until medical personnel arrive.
- **Do not remove** frozen gloves, shoes, or clothing.
- **Do not massage** affected part(s).
- **Do not expose** affected part(s) to temperatures above 112 °F (45 °C).
- **Do not apply** ice, snow, or ointments to affected part(s).

6.2.5. **Smoking is not permitted** in Building 4623. The test area is generally an oxygen-enriched environment. Open flame or other high-temperature sources are not permissible in the testing area while enriched-oxygen conditions exist. Personnel **shall not smoke or expose clothing** to an open flame for 30 minutes after handling liquid or gaseous oxygen.

6.2.6. The building warning system **shall be activated** for the duration of all testing, including pre- and post-test procedures. Personnel **shall evacuate** the test area immediately when the oxygen alarm sounds and lights flash.

6.2.7. *In case of an uncontrollable LOX fire*, personnel **shall not try to extinguish the fire but shall evacuate** the area immediately and shall **call 911** to notify the fire department.

6.2.8. Nothing shall be stored in the test cell area other than parts or components of the testing apparatus that are designated as spare parts and the tools necessary for routine equipment maintenance. All other materials shall be removed from the test area. Any spare parts that will be exposed to an enriched-oxygen environment shall be placed in the secured inventory area.

6.2.9. Personnel shall **ensure** that the ventilation system fan is on continuously during testing, including pre-test and post-test activities, to bring in fresh air and remove fumes and other combustion by-products from the test cell.

6.2.10. All testing shall be performed **remotely**. No one shall be allowed in the test cell during a test. Only the test operator(s) shall be allowed in the test cell during pre-test and post-test activities. Sample technicians are allowed to prepare liquid samples for testing. Other people shall be allowed in the test cell before and after testing as allowed by the test engineer.

6.2.11. Personnel shall **ensure** all electrical components, wiring, *etc.,* are in good condition and properly connected and grounded and shall **use caution** when operating any electrical equipment. Electrical devices shall not be operated when floors in the test cell are wet.

6.2.12. Glass dewar flasks shall not be used for the transfer of cryogenic fluids. (**Refer** to step 4.4.9 of this work instruction.)

6.2.13. All equipment that will contact LOX shall be cleaned as described in section 9.3, Required Tester Maintenance, and section 4.3, Equipment Checkout, before the equipment is exposed to LOX.

6.2.14 When handling cylinders and dewars or making connections for compressed gases and/or liquids, personnel shall **refer** to *Working Safely with Compressed Gases and Cryogens* and *NSTC 313-Cryogenics Safety* and shall **comply** with the suggestions inside these presentations. (The test engineer has these resources.)

6.2.15. The building warning lights **shall be checked** daily for proper operation.

6.3 Special Hazards Associated with Compressed Gases and Liquids

6.3.1. All operations involving compressed gases and liquids shall be conducted with at least 2 people, in visual contact, in the facility.

6.3.2. All operating personnel shall be instructed on the nature of hazards associated with compressed gases and liquids.

6.3.3. Before removal of any component of the system for servicing, the *operator* **shall secure and inspect** the system to ensure that no unsafe condition exists.

6.3.4. Personnel shall perform continuous monitoring, *e.g.,* check operating pressures, look for leaks, listen for unusual noises, during all operations. Personnel shall ensure that oxygen leak levels are adequate throughout operations.

6.4 Emergency Shutdown Procedure

The tester does not have to be shut down to be considered safe in an emergency situation.

6.5 Accident Reporting

6.5.1. From a safe location, the *test operator* **shall call 911 immediately** and **notify** the EM10 Branch Chief.

6.5.2. From a safe location, the EM10 Branch Chief **shall immediately report** the accident to the NASA Safety Monitor and the appropriate supervisor(s).

6.6 Emergency Response Plan

Emergency procedures and plans for Building 4623 are incorporated into this OWI and are stated in MPR 1040.3, *MSFC Emergency Plan,* current revision. Plans shall be modified if operations change in a significant manner.

6.7 Mishap Reporting

All mishaps occurring in Building 4623 **shall be reported** to the test engineer, who shall report the mishap to the Building 4623 Safety Monitor. An initial verbal report **shall be made** within 8 hours, followed by a written report within 3 days. The EM10 Branch Chief **shall prepare** a managerial report within 7 days. Both reports **shall be reviewed** by the test operator's supervisor and by the NASA Safety Monitor. The detail and extent of the mishap report **shall** depend on the nature and extent of the damage. *If personnel injury or equipment damage does occur*, the mishap report **shall** be completed in accordance with MWI 8621.1, *Close Call and Mishap Reporting and Investigation Program, current revision*.

7.0 Attachments, Data, Reports, and Forms

7.1 Attachment: Striker Pin Boxing Guide

This section describes the proper procedure for boxing striker pins for LOX cleaning. When two or more boxes of pins (~600) accumulate, they **shall** be sent for LOX cleaning, reducing the amount of batch testing. This boxing guide has been developed to allow:

- shipping boxes to be stacked without the bottom boxes being crushed
- ease of handling
- moving by hand truck
- quick count of pins.

The test operator **shall perform** the following steps:

7.1.1. **Mark** the number of pins in each rack with a permanent marker on the side of each rack.

7.1.2. **Pack** the racks in the special-purpose fiberboard shipping box, FSN 8815-00-117-8249 (a white file folder box with hand holes on the sides).

7.1.3. **Place** two rows of five racks across the width of the box. **Orient** the racks so that the pins are on their sides.

7.1.4. **Place** two racks flat on top of the two lower rows. This makes a maximum of 12 racks per box.

7.1.5. **Do not tape or seal** the boxes, since the pin count must be verified before the box is accepted at LOX cleaning.

7.2 Forms

Figures 1, 2, and 3 contain typical forms used in support of Test 13A. Table 1 defines the standard thresholding procedure for Test 13A. Table 2 provides test information for other possible test parameters.

Ambient Pressure LOX Impact Tester Pre-Test Checklist

Request No. _____

	Initial Yes	Initial No
1. NASA-STD-6001 reviewed?	☐	☐
2. OWI reviewed?	☐	☐
3. All safety equipment available and working properly?	☐	☐
4. Test equipment checked out per OWI?	☐	☐
5. Sample MSDS read?	☐	☐
6. Test plan read and changes noted and approved by engineer?	☐	☐
7. Adequate supplies of LOX and LN_2?	☐	☐
8. Pins checked for surface roughness/contamination?	☐	☐
9. Facility warning beacon activated?	☐	☐

Remarks/Discussion of Discrepancies:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ _____

Test Operator Date

1/05 EM10-F-CHM-030

Figure 1.
Typical Test 13A
Pre-Test Checklist.

Note: Representative Data Sheet. Refer to Forms Master List for current version.

Figure 2.
Typical Test 13A
Test Data Sheet.

TEST 13A TEST DATA SHEET

Sample preparation information

Test No.: _____ Date: _____ Project: _____
Request ID No.: _____ Requestor: _____
Manufacturer's Designation: _____
Manufacturer: _____ Batch: _____ Lot: _____
Composition: _____
Specification: _____
Substrate Material: _____ Substrate Thickness (in.): _____
Insert Cup Material: _____ Specimen Cup Material: _____
Cure Time: _____ Cure Temperature (F): _____ Cure Pressure (psia): _____
Sample: Ave. diameter (in.) _____ Length (in.) _____ Width (in.) _____ Inserts Used: Y ☐ N ☐
Ave. weight (g) _____ Thickness (in.) _____

Test operator information

Drop Height (in.) _____ kg-m: _____ Environment: _____

Test results

Sample #	Drop Time (s)	Flash*	Audible*	Odor	Char**	Reaction***	Comments
1							1
2							2
3							3
4							4
5							5
blank							blank
6							6
7							7
8							8
9							9
10							10
blank							blank
11							11
12							12
13							13
14							14
15							15
blank							blank
16							16
17							17
18							18
19							19
20							20

*S1 = 1st Impact; R1 = 1st Rebound; R2 = 2nd Rebound; R3 = 3rd Rebound
**S = Sample; C = Cup; P = Pin; I = Insert
***Complete last. 0 = No; 1 = Yes

Excess Sample?: Y ☐ N ☐
Quantity of Excess: _____
Test Summary (reactions/test): _____ at ft-lb: _____ Test Operator: _____

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Note: Representative Data Sheet. Refer to Forms Master List for current version.

Calibration Statement: Categories IV and V Equipment

Calibration is required before use per MPR-8730.5.

(Calibration before use for each test series and periodic testing by the Using LIne Organization)

Calibration Contacts: EM10/James Perkins, EM10/Mark Griffin

User Name:_____

Equipment Description:_____

(attach multiple components sheets if necessary)

Manufacturer:_____

ECN:_____ Serial No.:_____ Model No.:_____

Date of Calibration:_____

Type of Software and Version:_____

_____

Listing of Standards Associated with Calibration:

_____

_____

_____

_____

_____

Are standards National Institute of Standards and Technology (NIST) traceable? ☐ Y ☐ N

Did calibration meet equipment manufacturer's specifications? ☐ Y ☐ N

Calibration was performed by:_____

Remarks:

_____

_____

_____

_____

_____

_____

_____

_____

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Figure 3.
Typical Calibration Statement.

Note: Representative Data Sheet. Refer to Forms Master List for current version.

Table 1.
Standard Free-Fall Times for Ambient LOX Tester.

Impact Energy[1]			Drop Height (in.)	Theoretical Free-fall Time (s)	Actual Free-fall Time (s)	+3% Error (s)
kg-m	ft-lb	Note				
9.9	72.0	2	43.3	0.475	0.442	0.455
7.6	55.0	3	33.0	0.415	0.379	0.390
5.5	40.0	4	24.0	0.354	0.319	0.329
3.4	25.0	5	15.0	0.280	0.248	0.255
1.4	10.0		6.0	0.177	0.144	0.148

Notes:
1. If no reactions are observed at a specific energy level, testing shall be conducted at the energy level directly above the passing energy level, i.e., if no reactions are observed at 10 ft-lb, increase energy to 25 ft-lb, if the material has not been tested at 25 ft-lb.
2. If 2 reactions occur in >10 drops, lower energy to 55.0 ft-lb. If 2 reactions occur in <10 but >5 drops, lower to 40.0 ft-lb. If 2 reactions occur in <5 drops, lower to 25.0 ft-lb.
3. If 2 reactions occur in >10 drops, lower energy to 40.0 ft-lb. If 2 reactions occur in <10 but >5 drops, lower to 25.0 ft-lb. If 2 reactions occur in <5 drops, lower to 10 ft-lb.
4. If 2 reactions occur in >10 drops, lower energy to 25.0 ft-lb. If 2 reactions occur in <10 drops, lower to 10.0 ft-lb.
5. If 2 reactions occur in ≤60 drops, lower energy to 10.0 ft-lb.

Table 2.
Other Free-Fall Times for Ambient LOX Tester.

Impact Energy		Drop Height (in.)	Theoretical Free-fall Time (s)	Actual Free-fall Time (s)	+3% Error (s)
kg-m	ft-lb				
8.9	65.0	39.0	0.451	0.416	0.428
8.3	60.0	36.0	0.433	0.399	0.410
6.9	50.0	30.0	0.395	0.360	0.371
6.2	45.0	27.0	0.375	0.340	0.350
4.8	35.0	21.0	0.331	0.296	0.305
4.2	30.0	18.0	0.306	0.274	0.282
2.8	20.0	12.0	0.250	0.218	0.224
2.1	15.0	9.0	0.217	0.184	0.189

8.0 Records

Records for Ambient LOX Impact testing shall consist of memoranda that contain test results and that are stored electronically in the Materials and Processes Technical Information System (MAPTIS).

8.1 Memoranda

Memoranda containing test results shall be retained indefinitely by EM10. These memoranda shall be stored electronically in the MAPTIS database and shall be accessible by test request number or memorandum number.

8.2 Calibration Records

Not applicable to Test 13A.

8.3 Maintenance of Records

8.3.1. Memoranda less than 10 years old shall be maintained in ready-access files in MAPTIS; memoranda 10 years old or older shall be automatically transferred to historical files.

8.3.2. Calibration records shall be maintained on site for a minimum of 10 years, filed and indexed by test request number. These shall be stored in a manner that will protect them, *e.g.*, in a test folder stored in a metal file cabinet. After 10 years, calibration records shall be transferred to historical files.

8.3.3. The original test records shall be saved for a minimum of 5 years.

9.0 Tools, Equipment, and Materials

9.1 Standard Configuration of Tester

The ambient-pressure LOX mechanical impact tester (Figure 4) is fastened to a 2-ft x 2-ft x 2-ft concrete pedestal. The tester itself is approximately 5.5 ft high, with a 1-in. thick stainless-steel baseplate attached. A 5.5-in. x 6.6-in. moat, 3.5 in. deep, is bolted to the baseplate. A 20-lb (±0.05-lb) drop-weight plummet is held between three upright columns and rides these columns on ball bearings. The bearings are attached to triangular webs at the top and bottom of the plummet body and bear upon the grooves in the upright columns. An electromagnet holds the plummet at the desired drop height. The magnet housing assembly can be moved vertically on a fourth column to a maximum height of 48 in. above the sample to obtain the required impact energy to the sample.

A pre-chilled specimen cup (Figure 5) containing one pre-chilled sample configured as described in EM10-OWI-CHM-042, *Test Sample Preparation for Testing in Building 4623,* is placed in the pre-chilled well, and LOX is ladled into the cup until the cup is filled. (Figures 6 and 7 show specimen hardware used in ambient impact testing. Refer to the Definitions section, page 3, for more information on these items.) The striker pin (Figure 8) is placed on top of the sample, and the striker pin guide is placed over the pin (Figure 9). The plummet is dropped onto the striker pin, which transfers energy to the sample in the specimen cup.

The hardware standard configuration is controlled by the *Ambient Mechanical Impact Tester Configuration Control Book*, which is controlled by NASA.

9.2 Procedure for Deviations

Deviations to the baselined tester configuration **shall have** NASA written approval. It is the responsibility of the test engineer to obtain the written approval. After written approval is received, the change shall be added to the *Ambient Mechanical Impact Tester Configuration Control Book*.

9.3 Required Tester Maintenance

The standard maintenance program for this test chamber and related control equipment is divided into weekly and as-required service. In addition, the program involves a maintenance log, calibration, and a required spare parts inventory. The test operator shall perform the following procedures:

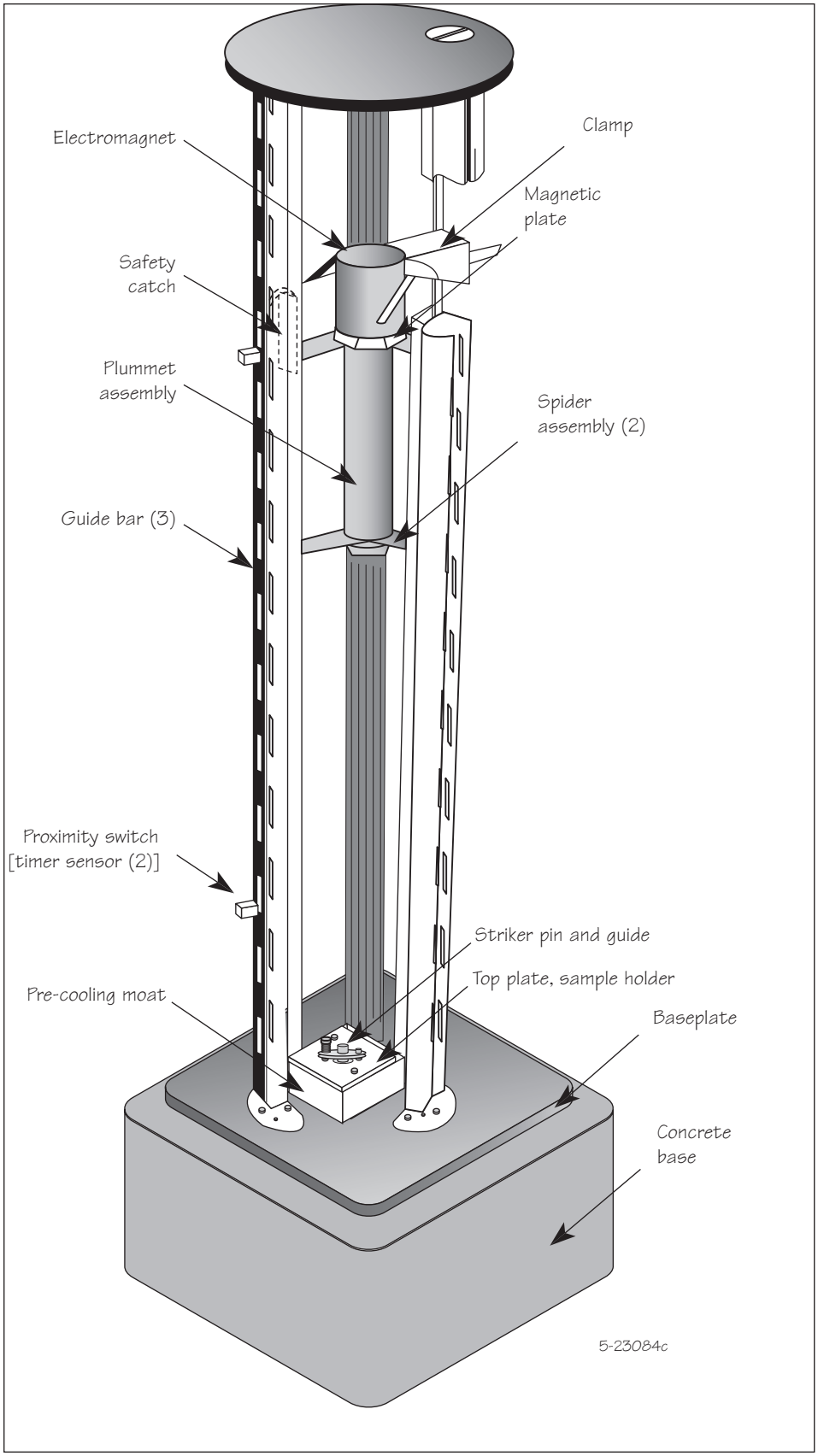


Figure 4.
Typical Ambient Pressure Mechanical Impact Tester.

Note: Illustration is representative. Actual appearance may vary.

Figure 5.
One-piece Specimen Cup.

Figure 6.
Insert Cup.

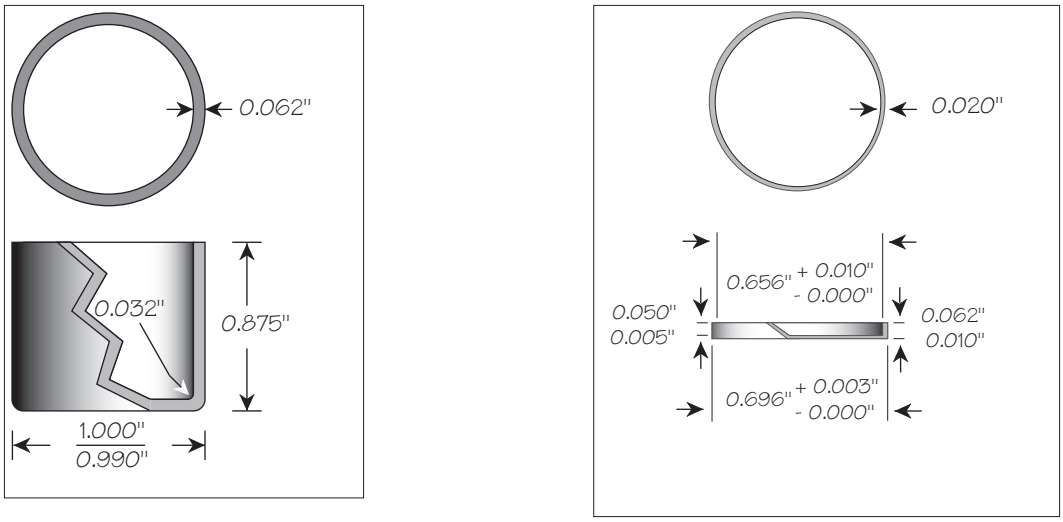


Figure 7.
Insert/Disk.

Figure 8.
Striker Pin.

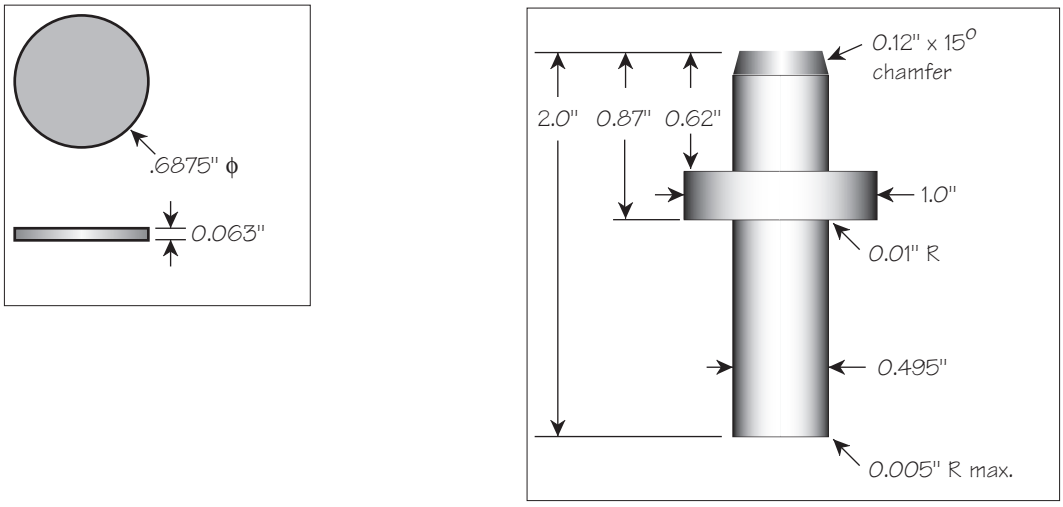
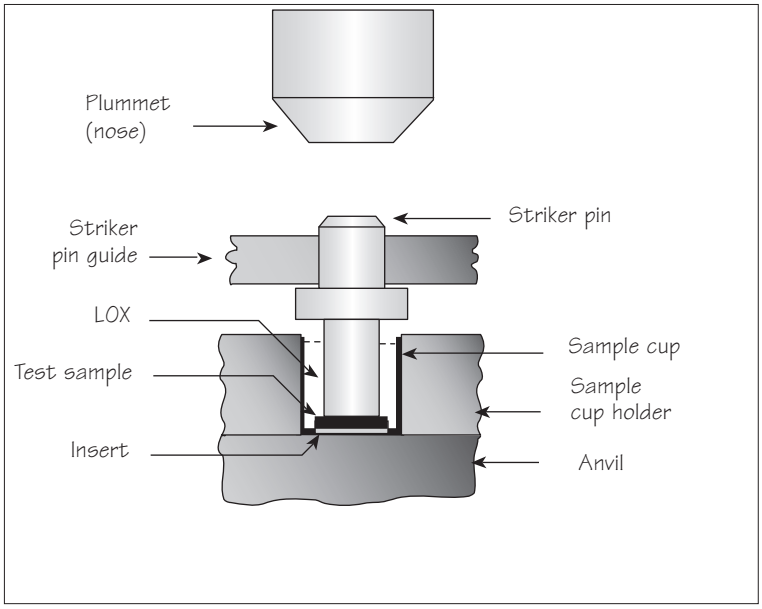


Figure 9.
Typical Sample Test Configuration.



Note: Illustrations are representative. Actual appearances may vary.

9.3.1. Weekly Maintenance. **Check** the dewar fill tube weekly to ensure there are no obstructions or kinks in the fill tube that would hinder proper operation. **Ensure** the cleanliness of the test area.

9.3.2. As-Required Maintenance

9.3.2.1. Using a visual comparator and the drawing specifications, **check** the finish of the post-test striker pin and specimen cup impact surfaces. *If necessary*, **send** the striker pin to the Fabrication Group for resurfacing. Pins shall always remain in their original rack (tolerance range), unless they are damaged or out of specification and, therefore, shall be discarded. (MSFC specifications are that the minimum distance from the top of the shoulder to the striking surface shall be 1.315 in.) **Do not replace** a discarded pin with a pin not in the tolerance range (0.005 in.) of the rack.

9.3.2.2. **Place** post-test pins in their original racks, **bag** them, and **tape** the bags closed. (See section 7.1 for striker pin boxing guide.) **Count and label** the number of pins on the bag with a permanent marker. **Prepare** a minimum batch of 600 pins as needed to go to the Cleaning Facility. Pins shall be cleaned to MSFC-SPEC-164B, *Specification for Cleanliness of Components for Use in Oxygen, Fuel, and Pneumatic Systems,* Class 1, Level A.

9.3.2.3. Newly machined cups and inserts shall be cleaned to MSFC-SPEC-164B, *Specification for Cleanliness of Components for Use in Oxygen, Fuel, and Pneumatic Systems,* Class 1, Level A. **Prepare** a minimum batch of 500 newly machined cups to go to the Cleaning Facility. **Bag** cups in groups of 25.

9.3.3. Maintenance Log. **Document** any maintenance to the test chamber or setup in the *Ambient-Pressure LOX Mechanical Impact Tester Maintenance Log* to provide a history of the tester. Any deviation to standard maintenance shall be documented by the test operator and approved on the maintenance log by the responsible test engineer.

9.4 Calibration

None.

9.5 Required Spare Parts Inventory

Verify that the spare parts listed in Table 3 are available at the beginning of each test request, so that the testing of a material can be completed as close to within 1 working day as possible.

Table 3.
Required Spare Parts Inventory for Test 13A.

Part	Quantity	Drawing #/Description
Bolt, Plummet Guide Bar	5	.25”-28 UNF x 2.125”
Bottom Plate, Anvil	1	B-D-1 Detail #1
Top Plate, Sample Holder	1	B-D-1 Detail #2
Moat, Pre-Cooling	1	B-C-2
Bolt, Anvil Assembly Hold Down	2	B-A-3
Stud, Striker Pin Guide Aligning	5	B-A-4
Stud, Striker Pin Guide Swivel	5	B-A-5
Nut, Striker Pin Guide Swivel	5	.250”-20 NC
Spring, Striker Pin Guide Swivel	2	1.5” x .470”
Guide, Striker Pin	5	B-A-6
Screw, Plummet Bearing Retainer	12	C-A-7
Bearing, Plummet	12	635 0394 V
Spring, Striker Pin Guide	1	N/A

10.0 Personnel Training

The nature of testing that occurs in Building 4623 is complex and involves potential hazards; therefore, all test operators shall complete the requirements for Category 1 Credentials before conducting any test, and all tester maintenance personnel shall complete the requirements for Category 2 Credentials.

- **Category 1 Credentials** qualify personnel to perform basic test operations.
- **Category 2 Credentials** qualify personnel to maintain and modify testing apparatus.

Category 1 Credentials - Basic Operations

To obtain Category 1 Credentials, the test operator shall complete training in following areas:

- High-Pressure Systems Safety
- Oxygen Compatibility
- General Safe Laboratory Practices
- Safe Handling of Cryogenic Fluids (LN_2 and LOX)
- Hazardous Waste Disposal.

Category 1 Credentialling also requires:

- Successful completion of an annual physical examination conducted by the medical facility at Marshall Space Flight Center (or equivalent), including a hearing exam
- A demonstration of knowledge of the test and equipment by the completion of two successful test sets under the supervision of the test engineer.
- A demonstration of knowledge of the OWI. Candidate test operators shall thoroughly read the test OWI and sign a statment confirming that they have read and understand the OWI. Each shall be issued a personal copy of the OWI.
- Passing of a written test covering the OWI. The test shall be administered by the test engineer.

A copy of the written test, along with the signed statement and the training record, shall constitute verification of credentials. Training records shall be kept on file as proof of training. These records shall include training expiration dates and required refresher courses.

Category 1 Credentials shall expire after a period of 2 years. After that time, recredentialling shall be required.

Category 2 - Tester Maintenance and Modifications

Personnel seeking **Category 2 Credentials** shall become qualified and credentialled through training classes approved by the candidate's supervisor or through training classes completed during previous employment. Training in the following areas shall be required:

- Compressed Gases and Working with Compressed Gas Lines and Fittings
- Basic Electrical Wiring.

This training shall be achieved through classes approved by the candidate's supervisor or through classes completed during previous employment.

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EMERGENCY PHONE NUMBERS

Emergency..... 911

Medical Center..... 4-2390

Industrial Safety..... 4-0046

Chemical Spills..... 4-4357

Safety Monitor
Building 4623..... 5-0358